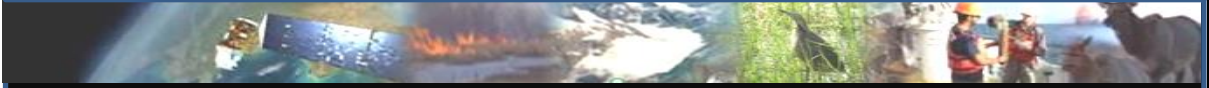


# Climate and Land Use Change

Understanding a changing world and how it impacts our natural resources, our livelihoods, and our communities



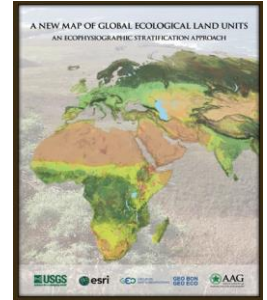
Newsletter

January 2015

## New Map of Global Ecological Land Units by Roger Sayre

The United States Geological Survey (USGS), Esri, the Group on Earth Observations (GEO), and the Association of American Geographers (AAG) are pleased to present A New Map of Global Ecological Land Units – An Ecophysiographic Stratification Approach. This paper describes the concepts and methods for

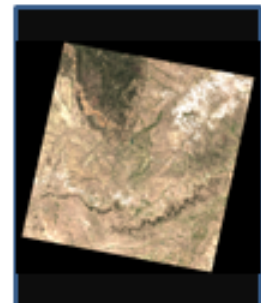
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## Landsat Science Products by John Dwyer

The Landsat archive represents more than 42 years of satellite observations of the Earth's land surface, with the highest quality calibrated record extending back to 1982 (Landsat 4) consisting of thematic mapper (TM) and enhanced thematic mapper (ETM+) data. The USGS, in collaboration with NASA and university. The

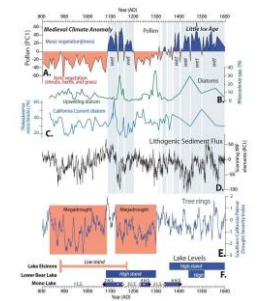
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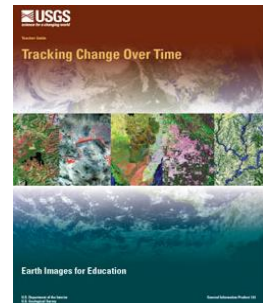
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### **Inspiring the Next Generation of Remote Sensing Scientists by Tom Adamson**

The Tracking Change Over Time lesson plan (GIP 133; <http://pubs.usgs.gov/gip/133/>) was produced by the USGS EROS Center for students in grades 5-8. The lessons enhance students' learning of geography, earth science, and problem solving by

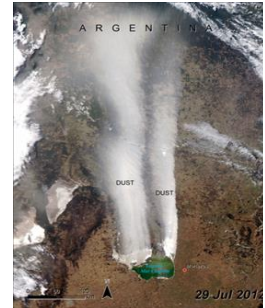
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### **Early Warning for Dust Storms by Lindsey Harriman**

Lindsey Harriman authored a chapter on early warning for dust storms in a book titled Reducing Disaster—Early Warning Systems for Climate Change published by Springer earlier this year. The book examines ways to protect people from hazards using early warning systems. Lindsey is a contractor to the USGS at the USGS

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### **Greenhouse Gas Fluxes of Grazed and Hayed Wetland Catchments in the U.S. Prairie Pothole Ecoregion by Raymond Finocchiaro**

The Prairie Pothole Region (PPR) situated within the northern Great Plains is well recognized for its highly productive agricultural environment and its wealth of natural resources.

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### **New Map of Global Ecological Land Units by Roger Sayre**

The United States Geological Survey (USGS) and Esri have collaborated to produce a new, high-resolution global ecosystems map. The Association of American Geographers (AAG) has published a print version of the paper describing the work – *A New Map of Global Ecological Land Units –An Ecophysiographic Stratification Approach*. The paper can be found at: <http://rmgsc.cr.usgs.gov/ecosystems/pubs.shtml> (USGS) or at [http://www.aag.org/cs/global\\_ecosystems](http://www.aag.org/cs/global_ecosystems) (AAG). The document contains the maps and also describes the concepts and methods for delineating Ecological Land Units (ELUs) as distinct physical environments and associated land cover. The ELUs were derived from a stratification of the earth into unique physical environments and their associated vegetation. A map of the ELUs of North and Central America is shown in Figure 1. The mapping approach first characterizes the climate regime, the landforms, the geology, and the land cover of the Earth, and then models terrestrial ecosystems as a

combination of those four land surface characteristics. The document contains detailed and accurate maps of ELUs for the Earth and the continents, as well as regional examples. The global map has a 250-meter spatial resolution.

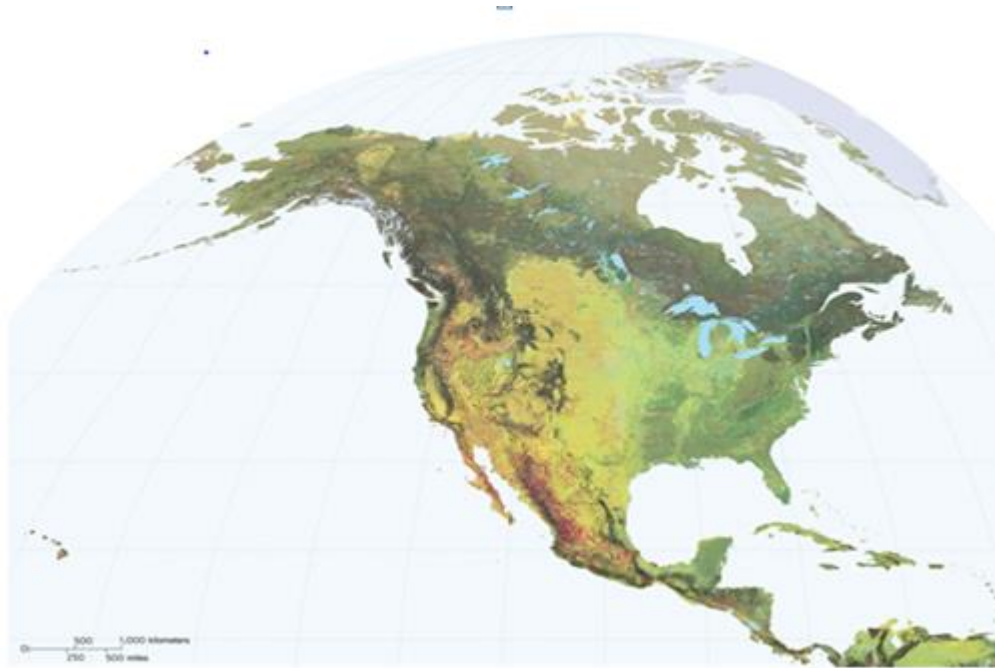


Figure 1. Map of ELUs of North and Central America

The ELUs were developed in response to the need for a high resolution, standardized, and data-derived map of global ecosystems for use in analyses of climate change impacts, assessments of economic and non-economic value of ecosystem goods and services, biodiversity conservation planning, and natural resource management. The work was done in a public/private partnership between USGS and Esri, and was commissioned by the Group on Earth Observations (GEO) as part of an intergovernmental protocol called the Global Earth Observation System of Systems (GEOSS). The data is downloadable in the public domain from USGS and also accessible from Esri's cloud-based ArcGIS Online, with powerful visualization environments, ecosystem tour and browser applications, and sophisticated online analysis tools.

The work is a classic example of a physical geography approach to understanding ecological diversity. *"A New Map of Global Ecological Land Units"* offers an unprecedented spatial delineation of nearly 4,000 ecological landscapes across the planet.

For more science from the Land Change Science Program visit:

[http://www.usgs.gov/climate\\_landuse/lcs/](http://www.usgs.gov/climate_landuse/lcs/)

## **Landsat Science Products by John Dwyer**

The Landsat archive represents more than 42 years of satellite observations of the Earth's land surface, with the highest quality calibrated record extending back to 1982 (Landsat 4) consisting of thematic mapper (TM) and Enhanced Thematic Mapper (ETM+) data. The USGS, in collaboration with NASA and university partners, has maintained the in-flight calibration of the Landsat instruments as well as data held in the historical archive. Now the Land Remote Sensing Program (LRSP) has undertaken the development of "Landsat science products" that are intended to be applications-ready datasets for use in monitoring terrestrial environmental conditions and to support the assessment of landscape vulnerability and resiliency to the impacts of climate change and human-induced influences.

In recent years the USGS has extended its collaboration with NASA and university partners to develop robust capabilities with which to transform the historical record. The result is that changes to the landscape can be detected and quantified. Biophysical parameters such as land cover, burned area and dynamic surface water extent can be retrieved. The available surface temperature data are expected to improve energy balance models used for the estimation of evapotranspiration and water use consumption in irrigated lands and for monitoring lake temperature for water quality assessment. See Figures 1 and 2 for examples of image transformation.

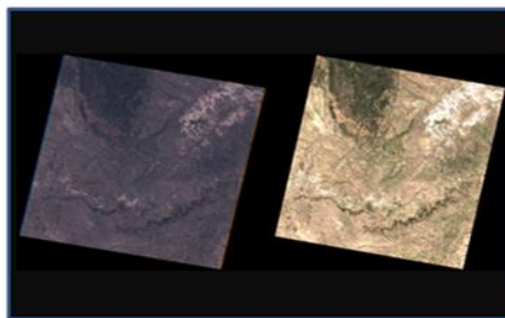


Figure 1. Landsat 5 Thematic Mapper(TM) image showing the transformed image of the southern Black Hills and Badlands of South Dakota

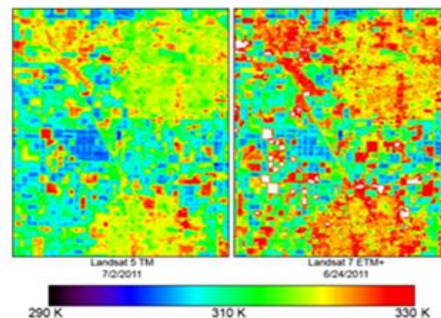


Figure 2. Surface temperature retrievals for an area in the Central Valley of California transformed image

Estimating above ground biomass through the integration of data from Light Detection and Ranging (LIDAR), Landsat 8 Operational Land Imager (OLI), and World View 2 and 3 high-resolution commercial satellite imagery. Similarly, research is being undertaken to estimate the fraction of snow covered area through the integration of Landsat and Moderate Resolution Imaging Spectroradiometer (MODIS) data. The result will be a high quality data set available to Earth scientists and land managers.



For more science from the Landsat Remote Sensing Program visit  
<http://remotesensing.usgs.gov/index.php>

For more science from the Earth Resources and Science Center visit  
<http://eros.usgs.gov/>

### **Vegetation Response to Past Southern CA Drought by John Barron**

USGS scientist John Barron was part of a team that performed high-resolution studies of pollen in laminated sediments deposited in Santa Barbara Basin (SBB). The sediments reflect decadal-scale fluctuations in precipitation spanning the interval from AD 800 - 1600. Over the past 15+ years continued radiocarbon dating and improved varve chronology has resulted in the development of an excellent chronology for SBB sediments, especially for the past 2,000 years. This chronology allowed the construction of a high-resolution comparison of marine and terrestrial environments at average 5-year sample spacing, see Figure 1. Correlative diatom and terrigenous sediment input proxy records from SBB are largely supportive of the pollen record predominantly linking the Medieval Climate Anomaly (MCA) with drought and La Nina-like conditions and the Little Ice Age (LIA) with wetter (more El Nino-like) conditions. These results support the comparison of the current drought in the southwest U.S. to those of the MCA, providing a means for possibly mitigating drought. Differences between paleoclimate proxies (pollen, diatoms, and terrigenous sediment) in SBB exist, possibly reflecting the temporal and spatial differences in the generation of each proxy record, as well as their individual sensitivity to climate change.

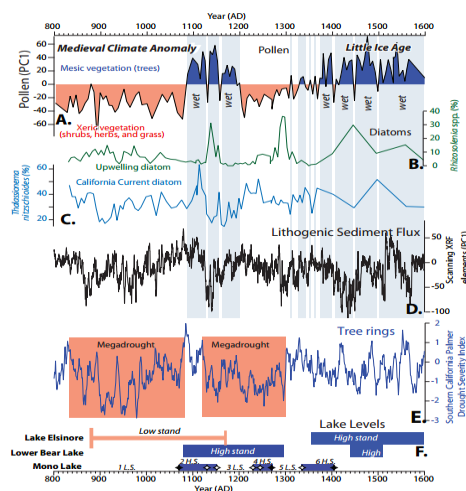


Figure 1. This figure compares SBB records of precipitation (pollen assemblages and Lithogenic flux) and oceanographic conditions (diatoms) with regional tree ring records of drought and California lake level records. It indicates that the Medieval Warm was regionally dry up until ~AD 1090 and the early part of the Little Ice Age was regionally wet after ~AD 1350. The intervening interval from ~AD 1090 to ~AD 1340 contains mixed wet and dry periods

A preview of the article is available at *Quaternary International*  
<http://www.sciencedirect.com/science/article/pii/S1040618214006806>

For more science from the Climate Research and Development Program visit  
[http://www.usgs.gov/climate\\_landuse/clu\\_rd/](http://www.usgs.gov/climate_landuse/clu_rd/)

### **Ecological Drought by Laura Thompson, Shawn Carter and Abigail Lynch**

The National Climate Change and Wildlife Science Center (NCCWSC) within the CLU Mission Area has chosen the emerging climate science field of Ecological Drought as a research focus area. Ecological drought is generally defined as the prolonged and widespread deficit in soil moisture or biologically available water that imposes multiple stresses in terrestrial and aquatic ecosystems. Significant impacts include: losses in primary productivity and



Figure 1. An ecological drought researcher electrofishing for Rio Grande Cutthroat trout, the southernmost cutthroat trout subspecies. Their habitat is threatened by climate change induced drought events.

biodiversity; altered rates of carbon, nutrient and water cycling; increased frequency, severity, and extent of ecological disturbances (such as wildfires and insect outbreaks); desiccation of springs and wetlands; local species extirpations and in some cases state transitions; vulnerability to biological invasion; changes in water quality; and diminished quality of wildlife habitat. Depending on the capacity of the particular ecosystem to withstand stresses (its resistance) and recover from the disturbance (its resilience), the legacy of ecological drought can carry over long (years to decades) after the

drought event has passed. Figure 1 shows a researcher studying a habitat threatened by climate change induced drought events.

Our understanding of ecological droughts is still in its infancy. There have been no comprehensive studies of ecological impacts, legacies, resistance, and recovery that involve comparisons across different sites, spatial scales, and biomes for a single drought, or comparisons of different droughts at the same site. NCCWSC aims to advance our knowledge on ecological drought. By sponsoring targeted 2013-2015 projects to generate capacity and assessment products (e.g., greenness information), NCCWSC will assess the current state of existing ecological drought research. Most of this work is internal to USGS (e.g., science centers and cooperative units). Additionally, NCCWSC has solicited projects through a 2015 RFP that will foster existing/new research

and highlight a range of ecological drought hypotheses and results to illustrate compelling ecological drought impacts from around the country and also highlight the value of NCCWSC-sponsored research.

For more science from the National Climate Change and Wildlife Science Centers visit <https://nccwsc.usgs.gov/>

### **Inspiring the Next Generation of Remote Sensing Scientists by Tom Adamson (EROS contractor)**

The Tracking Change Over Time lesson plan (GIP 133; <http://pubs.usgs.gov/gip/133/> ) was produced by the USGS EROS Center for students in grades 5-8. The lessons enhance students' learning of geography, earth science, and problem solving by seeing landscape changes from space. The goal is to inspire the next generation of remote sensing scientists by introducing students to the practical application of Landsat satellite data and how scientists use Landsat images to monitor changes on the Earth's landscape. Tracking Change Over Time is flexible and may be used as a student self-guided tutorial or as a teacher-led class lesson.

The lesson plan includes an introduction to satellite images, an introduction to remote sensing, instructions on how to use the free software MultiSpec, and modules that go deeper into specific areas of remote sensing application. In the module "Urban Area Change—Phoenix, AZ," students discover how Phoenix grew and/or changed from 1991 to 2010. The module takes a problem-based approach to show students how satellite images can be used to solve problems related to urban change and to gather information for urban planning. In the module "River Flooding," students discover how a flood in June 2008 affected southern Indiana and Illinois. This module shows students how satellite images can be used to analyze flood damage, extent, subsidence, etc. Each module also includes a scavenger hunt, which challenges the students to find various features in the Landsat images.



Answers are provided for the teacher with latitude-longitude coordinates. The images used in the lesson, along with supplementary materials, are also available at <http://eros.usgs.gov/educational-activities>.

For more science from the Landsat Remote Sensing Program visit <http://remotesensing.usgs.gov/index.php>

For more science from the Earth Resources and Science Center visit <http://eros.usgs.gov/>

### **Early Warning for Dust Storms by Lindsey Harriman (EROS contractor)**

Lindsey Harriman authored a chapter on early warning for dust storms in a book titled *Reducing Disaster—Early Warning Systems for Climate Change* published by Springer earlier this year. The book examines ways to protect people from hazards using early warning systems. The chapter addresses the importance of the continuation of research on early warning systems for dust storms.

Dust storms in different regions across the globe have high interannual, as well as annual and decadal, variability thus furthering the need for more research to be conducted over longer periods of time to analyze trends of occurrences and associated severity. The origin of dust storms, whether natural or human, and how aerosol circulation patterns are affected, also needs to be evaluated to understand the ultimate impact on the global climate.

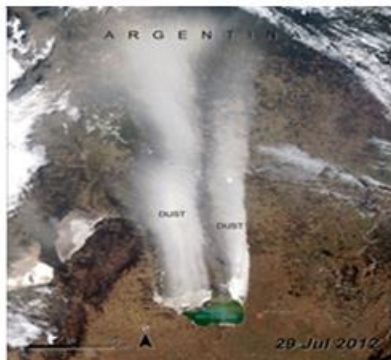


Figure 1. A dust storm occurred on July 29, 2012 near Laguna Mar Chiquita due to low lake levels and exposed, dried out sediment (NASA MODIS Aqua image, NASA 2012)

Dust storms can affect the land, water, and people from a great distance. They can cause disruption to communication, and car and air traffic. Airborne particles from dust storms can harm human health and can damage crops. Dust storms have become a bigger problem due to the increasing influence of human activities, seasonal variations, and long-term climatic patterns. A dust storm from an area affected by drought is seen in Figure 1. Dust storms occur in many regions but some areas of the world are more affected than others. Unfortunately these vulnerable areas are often less resilient and disaster recovery is not easy. Better early warning systems are especially important to minimizing the damage to these vulnerable areas.

See [http://link.springer.com/chapter/10.1007/978-94-017-8598-3\\_8](http://link.springer.com/chapter/10.1007/978-94-017-8598-3_8) for a preview of the article.

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## Greenhouse Gas Fluxes of Grazed and Hayed Wetland Catchments in the U.S. Prairie Pothole Ecoregion by Raymond Finocchiaro

The Prairie Pothole Region (PPR) situated within the northern Great Plains is well recognized for its highly productive agricultural environment and its wealth of natural resources. See Figure 1 for a map outlining the PPR.

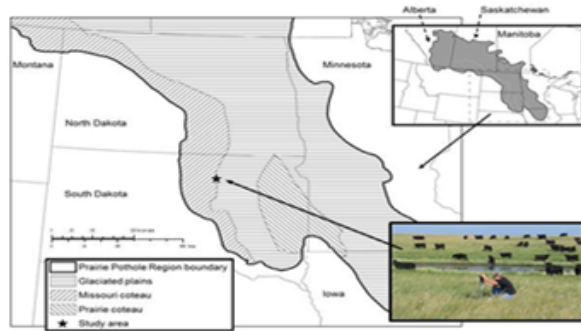


Figure 1. Outline of the U.S. portion of the PPR with inserts showing the outline of the entire PPR and a grazed wetland catchment in Southern Dakota included in the study.

Wetlands of this region are prominent ecosystems that provide numerous ecosystem services such as carbon sequestration, wildlife habitat, flood-water storage, and play an important role in regional greenhouse gas (GHG) budgets. Of the approximately 900,000 km<sup>2</sup> that make up the PPR, a large proportion of pre-settlement wetlands have been lost or severely degraded by development and remaining wetland catchments often are

situated in agricultural settings, including croplands and managed grasslands. The fundamental goal of many private conservation organizations and government agencies in the PPR is to preserve or restore tracts of grasslands and wetlands that are of lesser agricultural value with the purpose of

maintaining or enhancing the provisioning of ecosystem services. Protection and restoration of these ecosystems can help mitigate increasing levels of atmospheric carbon through avoided loss and sequestration. However, native and restored grasslands and wetlands controlled by conservation groups often are managed for grazing to fund land acquisitions and may be periodically hayed. Overall, grazing and haying land-management practices, when administered properly, can have little to no impact on various ecosystem services such as wildlife habitat and water storage. However, the effects of these common land-management practices on wetland processes (i.e., GHG flux) and related ecosystem services, such as carbon sequestration, are sparsely reported despite the fact that grazing and haying account for approximately 57,000 km<sup>2</sup> in the U.S. portion of the PPR. Grazing and haying

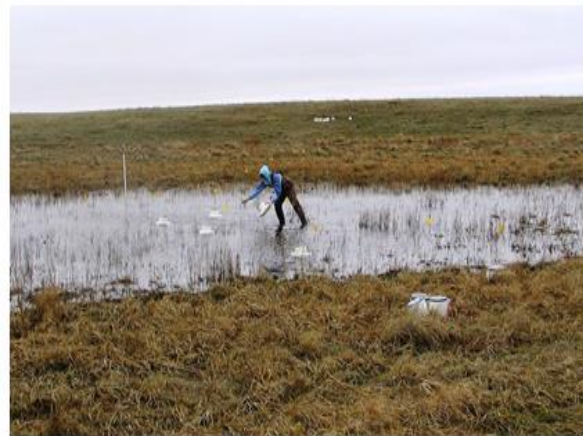


Figure 2. USGS technician deploying gas collection chambers in a grazed wetland catchment included in the study

effects on GHG fluxes of wetland catchments were examined in native and restored grasslands located in northeast South Dakota during 2007 and 2008. Gas collection chambers in a grazed wetland catchment are shown in Figure 2. Methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), and carbon dioxide (CO<sub>2</sub>) fluxes of soil and plant respiration, along with soil conditions, were measured in catchments that were grazed, hayed, or left idle. Ground-based gas collection chambers were used to measure fluxes. When compared with idle catchments, grazing as a land-use had little effect on GHG fluxes. Likewise, haying had little effect on fluxes of CH<sub>4</sub> and N<sub>2</sub>O compared with non-hayed catchments. Haying, however, did have a significant effect on CO<sub>2</sub> flux in wetland catchments owing to the immediate and comprehensive effect haying has on plant productivity. This study also examined soil conditions that affect GHG fluxes and provides cumulative annual estimates of GHG fluxes from wetland catchments in the PPR.

The report was published in *Wetlands Ecology and Management* and is available at: <http://link.springer.com/article/10.1007/s11273-013-9331-5/fulltext.html>

For more science from the Climate Research and Development Program visit [http://www.usgs.gov/climate\\_landuse/clu\\_rd/](http://www.usgs.gov/climate_landuse/clu_rd/)